# Scope of Work (Extracted from the original Contract)

# Climate Monitoring, Modeling, and Analyses: Phase III And 2008 Scenarios Impact and Adaptation Study

#### **GLOSSARY**

Specific terms and acronyms used throughout this work statement are defined as follows:

| Acronym | Definition                                    |
|---------|---|
| BLM     | Bureau of Land Management                     |
| CALVIN  | California Value Integrated Network           |
| CPR     | Critical Project Review                       |
| GHG     | Greenhouse Gas                                |
| GIS     | Geographic Image System                       |
| IPCC    | Intergovernmental Panel on Climate Change     |
| MS      | Microsoft                                     |
| SLR     | Sea Level Rise                                |
| SWAP    | Statewide Agricultural Production Model       |
| UCC.1   | Uniform Commercial Code (Financing Statement) |
| VIC     | Variable Infiltration Capacity                |
| WA      | Work Authorization                            |
| WEAP    | Water Evaluation And Planning system          |

# **GOALS OF THE AGREEMENT**

The goal of this Agreement is to improve scientific understanding of how climate is changing in California, improve capabilities of monitoring these changes, and to guide the development of climate projections for the State. The research described in this Agreement will provide guidance to the state on the steps that must be taken to adapt to expected environmental changes due to global warming. In addition, the research will describe the effects of climate change to the economy of California. The overall goal of the research is to inform ongoing and future climate change policy development and decision making. The final work product will be a scientific report to the Governor and the Legislature by the end of 2008.

#### **OBJECTIVES OF THE AGREEMENT**

The objectives of this Agreement are the following:

- Improve our understanding of how climate is changing
- Install monitoring stations in key areas in the state to monitor how climate is changing in California.
- Provide policy relevant information to state, regional and local climate change policy and planning efforts.
- Prepare a high quality scientific report for the Climate Action Team.

# Task 2: Observe watersheds and mountain transects

# Task 3: Archive and process California climate data

# Task 4: Study San Francisco Bay meteorological and sea level conditions

The goal of this Task is to investigate sea level conditions on open coast and in the San Francisco Bay, and the combined effect of sea level and riverine runoff.

#### The Contractor shall:

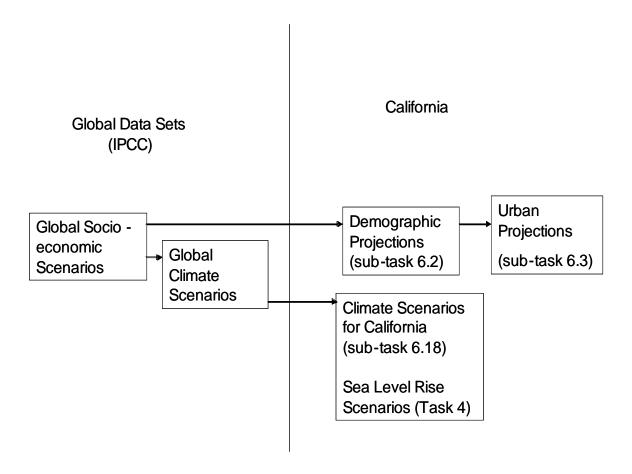
- Investigate flood mechanisms and changes in flood frequency of coastal and Sierra watersheds, including an evaluation of atmospheric circulation changes.
- Produce a Water Level Extremes Technical Paper. This paper shall include, but not be limited to, the analysis of observed water level extremes in the San Francisco Bay and Sacramento-San Joaquin Delta region, and include the effects of both sea level rise and freshwater flooding.
- Produce web-accessible Interactive Maps of maps of shoreline water level exceedance frequencies, corresponding to critical heights such as storm drain weirs in San Francisco, and a projection of changes in Delta levee overtopping potential. Scripps will maintain these maps for the duration of this Project.

# Task 5: Study extreme temperature and precipitation events

# Task 6: Prepare the 2008 Scenarios Project

The goal of this Task is to produce the different studies that are needed to produce the 2008 scientific report on impacts and adaptation that are needed to comply with Executive Order S-3-05 (p2).

For the 2008 Scenarios Project, the research team will develop population and urban projections that are in general agreement with the global scenarios developed by the Intergovernmental Panel on Climate Change (IPCC). These global IPCC scenarios are socioeconomic scenarios for the Earth as a whole. The research group will also develop climate and sea level rise scenarios for California that are compatible with the IPCC scenarios. Each IPCC scenario is linked to a global climate scenario which will be downscaled to the California region (see the figure below).



The research team will use the demographic and urban projections and the climate and sea level rise scenarios for California in their impact and adaptation studies.

Unless otherwise specified, all Papers and Reports prepared under this task shall:

- Require a first and second draft prior to the final paper or report. Both drafts will be prepared in accordance with the requirements in Task 1.5.
- Include an Executive Summary for policy makers, describing the implications of the research for California climate change policy.

# SubTask 6.1: Study projected California demographic impact

The goal of this Task is to develop population and household projections for California and its counties that reflect certain IPCC scenarios.

#### The Contractor shall:

Per TAC input, develop population and household projections for California and its
counties to 2100. The projections will include age, gender, ethnicity, and national origin.
A cohort component model will be used in which the population is aged over time by
applying mortality and migration rates.

- Develop population projections for every five years from 2005 to 2100. Existing national
  and global population projections will be used to estimate the size of populations that are
  the source of migrants to California. Past trends in migration, fertility, and mortality rates
  in California will be used to develop future rates, with some adjustments made to reflect
  selected IPCC scenarios.
- Correlate, to the extent possible, population projections with data on predicted changes in water supply, land use and energy availability due to climate change in California.
- Use alternative assumptions (e.g., immigration rates to California) to develop several series of population projections, providing plausible ranges of future population change.
- Incorporate to the extent possible this work into the projections work done in other Tasks, including land use forecasts.
- Prepare a Projections of California Demographics Report which analyzes and summarizes the work performed in this task. This Report does not require an Executive Summary.
- Compile a Population Projection Database consisting of population projections disaggregated by year, county, age, gender, ethnicity, and national origin.

# SubTask 6.2: Study projected California housing density impact

The goal of this Task is to develop a spatial database of allocated population, specifically housing stratifications that reflect the selected IPCC scenarios in California.

#### The Contractor shall:

- Per TAC input, develop public domain housing density data and maps at the sub-county level to reflect population projection scenarios. The housing density maps will reflect the population changes from 2000 to 2100 at the sub-county scale and the expected housing type.
- Generate a series of spatial databases in native GIS form that will reflect the location of population and households under each IPCC scenario. The spatial data will be developed at 5-year intervals and will take into account work previously performed by Landis et al. (Appendix III. How We Will Grow: Baseline Projections of California's Urban Footprint through 2100, http://www.energy.ca.gov/pier/final\_project\_reports/500-03-058cf.html) and others. Spatiotemporal interpolation methods will be drawn from readily-available methods.
- Prepare a California Housing Density Projection Report which analyzes and summarizes the work performed in this task.

# SubTask 3: Study water management impact and adaptation

The goal of this Task is to expand the geographic coverage of available WEAP (Water Evaluation and Planning) applications by focusing on developing an application of the west side of the San Joaquin Valley. This application will focus on representing the combined use of scarce surface water and available groundwater in a manner that reflects the hydrologic realities of this system where a saline unconfined aquifer is managed via the use of drains and an underlying confined aquifer is managed as an agricultural water supply. The model will be used to study potential impacts and adaptation options.

#### The Contractor shall:

- Per TAC input, develop and implement a methodology within the WEAP model to approximate the hydrologic effects of agricultural drains.
- Configure appropriate WEAP catchments of the western San Joaquin Valley.
- Develop a representation of the San Luis Reservoir in WEAP.
- Link the WEAP application of the western San Joaquin Valley to the existing Sacramento Valley application.
- Incorporate the economic analysis provided by UC Berkeley under Agreement (PIER Contract #500-99-013, Work Authorization BOA-119 Amendment 2) with the Energy Commission in the WEAP model. These economic analyses will focus on representing the drivers and controls on groundwater management in the region in a manner that allows for the simulation of future cropping patterns, water use patterns, and potentially agricultural land retirement patterns.
- Test, replicate, and validate until acceptable by the TAC the version of the WEAP model which incorporates (info from above) to make sure it corresponds with historical conditions.
- Conduct at least three studies using the climate change scenarios developed in this Project, using the socio-economic scenarios developed under Task 6.2 and the corresponding urban, suburban, and exurban projections under Task 6.3.
- Prepare a Water Management Adaptation to Climate Change Report which analyzes and summarizes the work performed in this task.

# SubTask 4: Study water supply economics and management

The goal of this Task is to investigate potential adaptation strategies for the water system in California using a new version of the CALVIN (California Value Integrated Network) model, a public domain software, that now includes the following important enhancements:

- Improved representations of groundwater resources:
- Inclusion of penalty function for flooding events;
- Consideration of sea level rise effects on salinity in the Delta region; and
- Updated water conveyance inter-ties for Bay Area cities and the Tulare Basin.

- Per TAC input, develop hydrologic inflows for the CALVIN model using the new climate change scenarios developed in this Project, and perform climate change runs using this
- Incorporate estimates of climate change on agronomic water demands and yields into economic value functions employed in the CALVIN model.
- Explore the costs of non-optimum responses of the water system imposing, for example, limited water markets that may be more politically feasible in an attempt to explore less optimum solutions that may be nevertheless more politically viable.
- Produce agricultural water delivery scenarios for different parts of the state for postprocessing by other models, including but not limited to, the Statewide Agricultural Production Model, in this Project,
- Coordinate this work, with the work done with the WEAP model under Task 6.4 (for example) suggesting adaptation strategies that could also be explored with the WEAP simulation model.
- Coordinate this with the studies on agricultural impacts.

- Use the climate change runs to study the potential impacts of climate change on water resources and investigate potential adaptation options.
- Estimate the potential impacts of climate change on high elevation hydropower units using the climate scenarios developed by Scripps.
- Produce a paper on the use of CALVIN. This report shall include, but not be limited to, discussions about potential impacts and adaptation options. This report need not include an Executive Summary.
- Produce a Climate Change Impact on High Elevation Hydropower Unit Paper. This report shall include, but not be limited to a discussion about the potential impacts of climate change on high elevation hydropower units and the identification of potential coping strategies.

# SubTask 5: Study sea level impact in the San Francisco Bay

# SubTask 6: Study forest ecosystem impact

The goal of this Task is to conduct two studies that will incorporate a multi-faceted biological and economic model to capture the most important drivers of the changes in timberland and forest ecosystem services.

#### The Contractor shall:

Per TAC input, conduct a California Timberland Study evaluating the potential impacts of climate change on California Timberlands. This Study shall build on the approach taken by Mendelsohn (2003, Appendix XII. A California Model of Climate Change Impacts on Timber Markets, http://www.energy.ca.gov/pier/final\_project\_reports/500-03-058cf.html).

The economic modeling conducted in this Study will examine the dynamics of land use change, land values, and changes in landowner management priorities. In addition, this Study will assess the policy implications of shifting timber species distributions and timber values on public lands. The analytical framework of Mendelsohn's approach will be expanded to account for changes in landowner management objectives and possible policy levers by, without limitation:

- o Incorporating information from multiple biological models, particularly a speciesbased model of biological effects of climate change;
- Using estimates of land use change available within the biological model to improve on previous assumptions of no change in land use;
- Encompassing both private and public timberlands, which considerably expands of the previous focus on private timberland only:
- Using more accurate and detailed timber price data by using price data for each timber species at the county level, as opposed to the statewide average approach used in previous studies;
- o Accounting for uncertainty in the biological model, economic model, and landowner management decisions through consensus modeling, stochastic optimization, and other techniques; and
- Prepare a Climate Change Impacts on California Timberlands Paper which analyzes and summarizes the results of the California Timberland Study.
- Conduct a California Forest Ecosystems Services Study. In the course of this Study, the Contractor shall:

- Assess potential impacts on forest ecosystem services that result from changes in the area, distribution, and values of private and public forests in California. These estimates will be derived from literature, current research, and estimates comparing current species composition and land use demand with species composition and land use demand calculated by the biological model for different climate scenarios.
- Assess current methods for valuing forest ecosystem services and their applicability to the forest ecosystem in California.
- To the extent of which data are available, consider the impacts of a greenhouse gas cap and trade system, with forestry offsets, on both timberlands and forest ecosystems in their studies.
- Prepare a Climate Change Impacts on California Forest Ecosystems Services Paper which analyzes and summarizes the results of the California Forest Ecosystems Study.

# **SubTask 7: Develop forest production models**

The goal of this Task is to perform a case study about the potential impacts of climate change on forest production and the identification of potential adaptation options. Highly productive and intensively managed conifer forests occur at the lower and mid-montane zone of the Sierra Nevada and southern Cascade mountain ranges in California. These forests provide carbon neutral construction wood and biofuels that contribute to long-term sustainability. The mills, logging and transportation infrastructure that these forests support are key components of the economic systems necessary to adapt to climate change. The developed models will incorporate uncertainty in measurements, ecological processes, methods, and projected climate scenarios, providing not an answer but a range of answers with a defined level of confidence.

- Per TAC input, update the forest growth models known as Forest Vegetation Simulator (FVS) for pine/mixed conifer timberlands.
- Develop models from data for specific sites that represent the range of timberlands. climates, and associated economies across the Sierran gradient.
- Generate climate-sensitive models that can interact with the Forest Vegetation Simulator, a nation-wide forest simulation provided by the United States Forest Service.
- Link scenarios of forest growth and mortality to relevant economic ramifications. For example, the higher value of the pine species, especially compared to the lesser value of cedar or fir, remains a major determinant of overall projected financial viability of potential adaptive strategies. This viability will depend on the economic value of precommercial and commercial thinnings as well as other biomass that increases the fire risk to existing stands. These sorts of questions can be addressed by using the ecological outputs to drive economic models like the USDA Forest Service's BioSum software package that links local inventories to facilities via regional transportation models.
- Assess the impact of a cap and trade market, with forestry offsets, on forest production.
- Prepare a Forest Production Models Report which analyzes and summarizes the work performed in this task, and additionally includes discussion on potential adaptation strategies.

# SubTask 8: Study climate change impacts on wildfire

The goal of this Task is to improve the studies of Westerling and Bryant's work on fire modeling and loss modeling (2006; 2007). Recent work has suggested that wildfire in California's forests and related property losses will increase substantially with climate change.

- Participate in a meeting/conference call with project staff working on demographic and development scenarios to discuss how to best coordinate and integrate their products into models for property losses due to wildfire. Based on the results of this meeting/conference call prepare, if needed, a revised description of the technical activities to be undertaken.
- Refine and evaluate the fire risk models used in the projections of Westerling and Bryant (2006 & 2007). The current models are empirically based on 1980-1999 downscaled climate data (temperature and precipitation) and simulated hydrologic data (soil moisture). The contractor will explore whether the use of products from new downscaling techniques and hydrologic simulations, as well as new hydrologic variables (Moisture Deficit), results in significant changes in model predictions.
- Refine and evaluate property loss models used in the projections of Westerling and Bryant (2006 & 2007). These models include estimates of property values based on US Census and county assessor parcel data, and estimates of damage ratios (percentage of threatened structures lost in a wildfire). The contractor will evaluate whether more detailed parcel data will improve property value estimates. The contractor will refine and evaluate models for estimating damage ratios as a function of housing density, fire risk, vegetation type and topography.
- Incorporate development scenarios in property loss estimates due to wildfire. Westerling and Bryant assumed the level and spatial distribution of future property values were fixed at the 2000 census. The contractor will evaluate the impact of incorporating a range of different development scenarios on property losses due to wildfire under a range of urban development scenarios.
- Evaluate the impact of changes in wildfire risks due to climate change on suppression costs. The contractor is developing models of fire suppression costs for Forest Service and Bureau of Land Management (BLM) budgeting and planning through the peak of the fire season in California and the western US that are driven by fire risk models and spatial variability in historical cost data. The contractor will apply these suppression cost models to fire risks modeled under climate change scenarios to estimate the effect of climate change on fire suppression costs in California. These results will assume that fire management strategies and resources do not change significantly over the study period (i.e., they will project the effects of climate change on costs given current fire management).
- Assess coping strategies in the form of different development patterns, and express their benefits in terms of property losses relative to a reference scenario.
- Prepare a Climate Change Impacts for California Wildfire Report which analyzes and summarizes the work performed in this task.
- To the extent possible, incorporate fire suppression strategies under development by the California Department of Forestry and Fire Protection,

# SubTask 9: Study end-user impact of extreme events

The goal of this Task is to improve existing research on the end-user impact of extreme events in California. It will focus on assessment of present and future changes to end-users (such as the power generation and agricultural sectors) in the likelihood of events similar in magnitude to historical events, and, to the extent possible, the likelihood of concurrent extreme events and events more intense than those observed historically.

#### The Contractor shall:

- Examine and synthesize the work of the various research groups that are conducting impacts work related to extreme events in California. The research team will:
  - o Rely on the TAC to define what constitutes an "extreme event" in each impact sector.
  - Coordinate with these groups to utilize their most recent relevant results, with an eye to judging the likelihood of extreme events of the same magnitude as key past events and how that might change in the future, ideally related in the same way as past impacts work in California to higher and lower emissions scenarios.
  - Rely on these groups to identify appropriate historical events to use in the analysis. This coordination may require an iterative process between the research team and each impacts group to acquire or generate needed data.
- Assess the likelihood of concurrent extreme events, relying to the extent possible on the results of the first task. Specifically, this study shall utilize:
  - historical data,
  - o model simulations of historical conditions and future projections, and
  - scientific judgments of relevant experts on the ranges and likelihood of future climate change that might alter the occurrence of extreme events, interactions between extreme events, and the likelihood of concurrent extreme events.
- Prepare a Changes in California Current and Future Extreme Events Report which analyzes and summarizes the work performed in this task.

# SubTask 10: Study Central Valley agricultural adaptations to climate change

The goal of this Task is to study potential adaptations to climate change in an agricultural landscape. The study will focus on Yolo County due to its representative cross-section of a Central Valley agricultural landscape, which encompasses the floodplain of the Yolo Bypass, intensive cropland of diverse horticultural and field crops, upland grasslands and savanna of the Blue Ridge, as well as urban and suburban communities.

- Assemble a group of scientists to form an interdisciplinary research team to investigate different issues contributing to sensitivity, vulnerability and adaptation to climate change in Yolo County, e.g., agricultural ecology, geographic information systems, hydrology, agricultural and resource economics, environmental policy, political science, and community development, and work with an advisory group to prioritize key issues for detailed study.
- Describe the current agricultural landscape of Yolo County using a variety of data sets and approaches that include present and historical land uses, agricultural commodities and production issues, income and livelihoods, relevant policies and institutions, population growth and urban and suburban issues related to agriculture.

- Develop a series of potential scenarios for adaptation to climate change in Yolo County, based on input from consultants, collaborators, and from similar projects in other Mediterranean climates. These scenarios will then be used to explore plausible outcomes and the vulnerability and adaptive capacity of the current agricultural landscape of Yolo County to climate change using regional outcomes from climate models for California, published literature, and information obtained from consultants from various stakeholder groups, including public agencies and nongovernmental organizations.
- Collaborate with other research groups in the 2008 Scenarios Project to integrate their modeling on crop production and economic outcomes into projections for Yolo County.
- Provide recommendations to the TAC on how to consider the role of public institutions, policies, regulations and laws on determining scenarios for adaptation to climate change, e.g., the Endangered Species Act.
- Evaluate the potential resilience to climate change for various types of land uses and landscape types, and for various segments of society, with an emphasis on tradeoffs that occur in relation to agricultural sustainability, i.e., agricultural production, environmental quality and social well-being.
- Prepare a Central Valley Agricultural Adaptation Paper which analyzes and summarizes the work performed in this task.

# SubTask 11: Study effects of climate change on Central Valley crop production

The goal of this Task is to use an ecosystem modeling approach to link land use, soil and climate data, and predict changes in crop yield in response to changes in the average and the variability of the temperature and precipitation regime in California. Predicting field crop yields in the coming century requires complex ecosystem modeling that integrates crop growth, nutrient dynamics, hydrology, management and climate.

- Characterize the Central Valley by dividing this region into 100 square kilometer grid cells, assigning to each cell soil and climate condition within a GIS framework, and identifying for each grid cell the proportion of crops cultivated. The crops included will be the main field crops, rice and vegetables, orchards, and vineyards. This approach will allow the contractor to simplify the regional modeling, integrate it with other available and forthcoming GIS databases, such as Scripps weather data and the California Value Integrated Network (CALVIN) water availability model.
- Determine soil and land use distribution, using the best sources of data available including land use information from:
  - o United States Department of Agriculture, National Agricultural Statistics Service (data at county level, and available every year),
  - Agricultural commissioners (data available for most counties per township-rangesection and available most years),
  - Department of Water Resources (data per field, but only available for selected counties and selected years).
  - o The Soil Survey Geographic Database from the Natural Resources Conservation Service, and
  - o Grid or county-level weather scenarios under climate change using the climate scenarios produced for 2008 Scenarios Project.

- Simulate the effects of climate change for each crop per grid cell. This simulation will
  utilize the DayCent model, an ecosystem model which has already been calibrated by
  the contractor for California conditions.
- Estimate uncertainties around crop responses coming from:
  - o Uncertainties around changes in climate,
  - Uncertainties due to year-by-year variations (e.g. due to extreme weather events such as heat spells), and
  - Uncertainties around soil and management input variables.
- Conduct scenario analyses to elucidate how growers could adopt by changes in management (i.e. changing planting data and fertilization regime).
- Estimate the effect of water availability using at least two scenarios:
  - o Availability of water for irrigation is non-limiting, and
  - Water availability is limited as predicted by the CALVIN model or similar models.
- Prepare a Climate Change on Crop Production in the Central Valley of California Paper which analyzes and summarizes the work performed in this Task.

# SubTask 12: Study economic impacts of climate change and adaptation options in the agricultural sector

The goal of this Task is to explore potential economic impacts of climate change and adaptation options in California's agricultural sector.

#### The Contractor shall:

- Per TAC input, configure the SWAP model in a way that could be used for climate impacts and adaptation studies. SWAP is a computer model that simulates transport of water, solutes and heat in variably saturated top soils.
- Use the climate scenarios and the water restrictions provided by other models (e.g., CALVIN and WEAP) to estimate impacts and adaptation options.
- Use the newly develop crop yield findings generated by Lobell et al. in the SWAP model.
- Prepare a Climate Change Economic Impact and Adaptation Options Paper which analyzes and summarizes the work performed in this Task.

# SubTask 13: Study economic impact on agriculture using econometric techniques

The goal of this task is to estimate the effect of the PIER climate change scenarios (see the description at the start of task 6) developed throughout this Project on California agriculture. The effect will be in terms of changes in the value of farm output at the county level, holding prices constant. To the extent data permits, effects will also be determined at the sub-county level.

- Estimate the effect of weather and climate on California agriculture using the profit function approach. At a minimum, this will be performed at the county level. Efforts will be made to extend the data to the ZIP code level, using Census of Agriculture data.
- Apply the climate change scenarios being generated by Scripps for this Project to the
  estimated relationship to determine the effect of the projected climate change on the
  value of the state's agricultural output, at least at the county level.
- Prepare a Climate Change Impact on California Agriculture Paper which analyzes and summarizes the work performed in this Task.

# SubTask 14: Study economic impact on Southern California beaches

The goal of this Task is to examine the impact of beach loss and erosion due to climate-driven sea level rise (SLR) in Los Angeles and Orange Counties.

Sea level rise (SLR), driven by global climate change, is likely to cause severe erosion and even the total loss of many low-lying beaches in California. Reduced beach width and total beach loss are known to result in substantial losses of economic value to beach goers, lost revenues for beach-related businesses, and even reductions in home values. While costly beach armoring may protect homes, only beach nourishment can replenish sand lost to erosion. Even beach nourishment may not be feasible for small pocket beaches that could be completely or seasonally flooded due to sea level rise.

#### The Contractor shall:

- Modify an existing model of beach recreation for southern California (Hanemann, Pendleton, and Mohn, 2006, "Southern California Beach Valuation Project") using newly acquired data on beach size being developed for an in-progress project on the economic value of beach nourishment to estimate the potential economic impact of beach erosion and beach loss in Southern California's Los Angeles and Orange Counties due to sea level rise. Specifically, for a variety of SLR scenarios this task will estimate changes in:
  - Day use attendance at beaches in Los Angeles and Orange County,
  - o The economic value (consumer surplus) enjoyed by day use beach goers, and
  - Expenditures by day use beach goers.
- Develop estimates of the potential cost of beach nourishment that may be employed to stem the loss of beach sand at vulnerable beaches in these counties.
- Estimate the potential net economic impacts on beach recreation of sea level rise for scenarios that also include adaptation to sea level rise using the above estimates of beach nourishment and the potential economic impacts of beach loss.
- Prepare a Climate Change Impact on California Beaches Technical Paper which analyzes and summarizes the work performed in this task.

# SubTask 15: Study impact of heat waves on mortality and morbidity

The goal of this task is to complete three studies relating temperature and heat waves to mortality and morbidity in California.

- Extend a study the contractor conducted for PIER on temperature-mortality research by identifying susceptible subgroups in the same nine California counties, using the same data set as a previous study submitted to PIER (Climate Change Impacts: Potential Impact of Height Temperatures and Air Pollution on Public Health, UC BOA-118-03).
- Compare mortality risk by age group (focusing on infants, young children, and the elderly), ethnicity, gender and education level.
- Conduct a study of temperature and mortality for the same six California counties that provided preliminary mortality data over the heat wave period in July 2006.
- Compare the result from this study with that of UC BOA-118-03, which estimated mortality risk in the warmer months from 1999 to 2003 without any clear heat waves.

- Develop a time-series study using statistical regression techniques using daily mortality counts from all causes and mean daily apparent temperature. Minimum and maximum daily apparent temperature shall also be considered. This effort will characterize the extent of the non-linearity of the dose-response estimate and whether empirical estimates based on non heat wave periods underestimate the effect of temperature extremes.
- Examine the association between temperature and morbidity using data from several California counties in the warmer months of 1999 to 2004. Specifically, analyze hospital admissions for all causes, respiratory diseases, cardiovascular diseases, cerebrovascular diseases, and diabetes; and evaluate possible differences by age group (primarily infants, young children, and elderly), ethnicity and gender.
- Prepare a Climate Change Impact on California Heat Waves Paper which analyzes and summarizes the three studies and associated work performed in this task.

# SubTask 16: Study future greenhouse gas (GHG) emission scenarios

The goal of this Task is to produce a report on future greenhouse gas emissions scenarios that includes usable probabilistic projections of emissions and radiative forcing pathways suitable for use in modeling future California climate. This report and the projections it contains will be based on both existing scholarly research - including methods for creating distributions of likely radiative forcing pathways – and a new survey of expert opinion. The report will also contain an appraisal of the robustness of the results and their implications for further modeling and policy analysis.

- Design survey questions to collect useable information in a variety of forms to account for the fact that not all of the experts likely to be surveyed believe that it is possible to represent future emissions projections probabilistically in a straightforward manner. For example, it will be necessary to devise protocols for eliciting expert opinion of the likelihood of the implementation of climate policy and the effectiveness of that policy in reducing emissions.
- Survey at least ten leading researchers with expertise regarding emissions scenario design, socioeconomic development, energy modeling, and trends in key regions using the survey questions designed above.
- Improve on a public domain working model previously developed at Stanford University which produces probabilistic estimates of pathways for radiative forcing, based on assumed distributions of parameters for the radiative forcing from aerosols and other non-carbon dioxide gases, and the future behavior of carbon sinks.
- Develop two sets of probability scenarios for future GHG emissions. One scenario will base its data upon "business as usual" projections developed by IPCC where the status quo is maintained. The second scenario will be based on aggressive GHG emission reductions, pursued beyond those outlined in the Kyoto Protocol. This second set of scenarios will be obtained from publications in the peer-reviewed literature and from direct contacts with the groups developing these new scenarios. For example, the US Climate Change Science Program recently developed new emissions scenarios that could be used under this contract. The TAC (see subtask 6.0) will assist the Commission Project Manager in selecting these new sets of scenarios.
- Prepare a report on Future GHG Emissions Scenarios which analyzes and summarizes the work performed in this task. This report shall include but not be limited to usable probabilistic projections of emissions and radiative forcing pathways suitable for use in modeling future California climate, and the two probability scenarios outlined above.

# SubTask 17: Downscale statistical techniques and hydrological modeling

The goal of this Task is to assist the TAC with the generation of climate change scenarios using the statistical downscaling technique used for the 2006 Scenarios Project and the Variable Infiltration Capacity (VIC) model, a public domain system, to translate these climatic scenarios into hydrologic outputs.

#### The Contractor shall:

- Downscale the selected outputs from global climate models to the California region using the same statistical downscaling technique used for the 2006 Scenarios Project.
- Compare the results of the prior statistical downscaling technique with the new statistical technique developed by Scripps for PIER ("Downscaling Daily Precipitation and Temperature Fields Over the US with Constructed Analogues." Draft PIER Report)
- Generate hydrologic scenarios using VIC.
- Provide the data to the different researchers working on this Project.
- Prepare a Statistical Downscaling Techniques and Hydrological Modeling Paper analyzing and summarizing the work performed in this Task.

# SubTask 18: Study impact of climate change on California agriculture and adaptation

The goal of this Task is to improve the study of Lobell et al. (2006. "Impacts of future climate change on California perennial crop yields: Model projections with climate and crop uncertainties") and perform an adaptation case study. Recent work has suggested that California's multi-billion dollar perennial crop industry may sustain significant yield losses due to climate change over the next 50 years.

- Refine and evaluate the crop models used in the projections of Lobell et al. The current models are empirically based on 1980-2003 data aggregated to the state level. The contractor will explore whether the use of data prior to 1980, as well as data at the county scale, results in significant changes in model predictions.
- Compare the predictions of the empirical models with those from more process-based crop models, such as used in assessments of future changes in water demand or biogeochemical fluxes. The results will provide a measure of the sensitivity of conclusions in the various studies to the type of crop model used.
- Evaluate the economic impacts of yield losses collaborating with the sectoral economic study described in Task 6.14. The contractor will collaborate as needed with the researchers providing work in Tasks 6.13 and 6.14 to translate yield scenarios into changes in crop prices and overall production. This will involve simulation of the various adjustments in crop prices, management practices, crop area, and crop substitution driven by yield changes.
- Perform an adaptation case study for almonds. Current model estimates do not consider adaptation efforts of growers, in part because of the long life-span of perennial crops. However, identifying adaptation options is critical not only for accurate projections, but for enabling growers to cope with expected climate change. As a case study of adaptation, the contractor will focus on almonds, one of the most valuable crops in California and almost certain to be affected by warmer temperatures. Specifically, the contractor will:

- Identify the relevant characteristics of the major almond varieties, such as their chilling unit requirements.
- Model the change in chilling units through time at different locations based on climate projections, and evaluate the relative suitability of the different varieties.
- o Identify varieties that become more or less suitable as climate warms
- Measure the potential risks of changing varieties. For example, growers that switch to varieties better suited to warmer temperatures may risk yield losses in the current climate.
- Prepare a California Crop Report which analyzes and summarizes the work performed in this Task.

#### SubTask 19: Other Studies

The goal of this Task is to cover one or more studies that the Scenarios Subgroup may decide to fund to complement the studies listed in the previous subtasks. For the PIER work for the 2006 Scenarios Studies some limited funds were available for potential new studies that could be uncovered during the execution of the overall research. This approach proved to be extremely useful.

The new studies will be mostly on economic impacts and adaptation options. Some of the studies that may be considered include, for example, an assessment of the impacts of sea level rise on coastal infrastructures.

500-07-017